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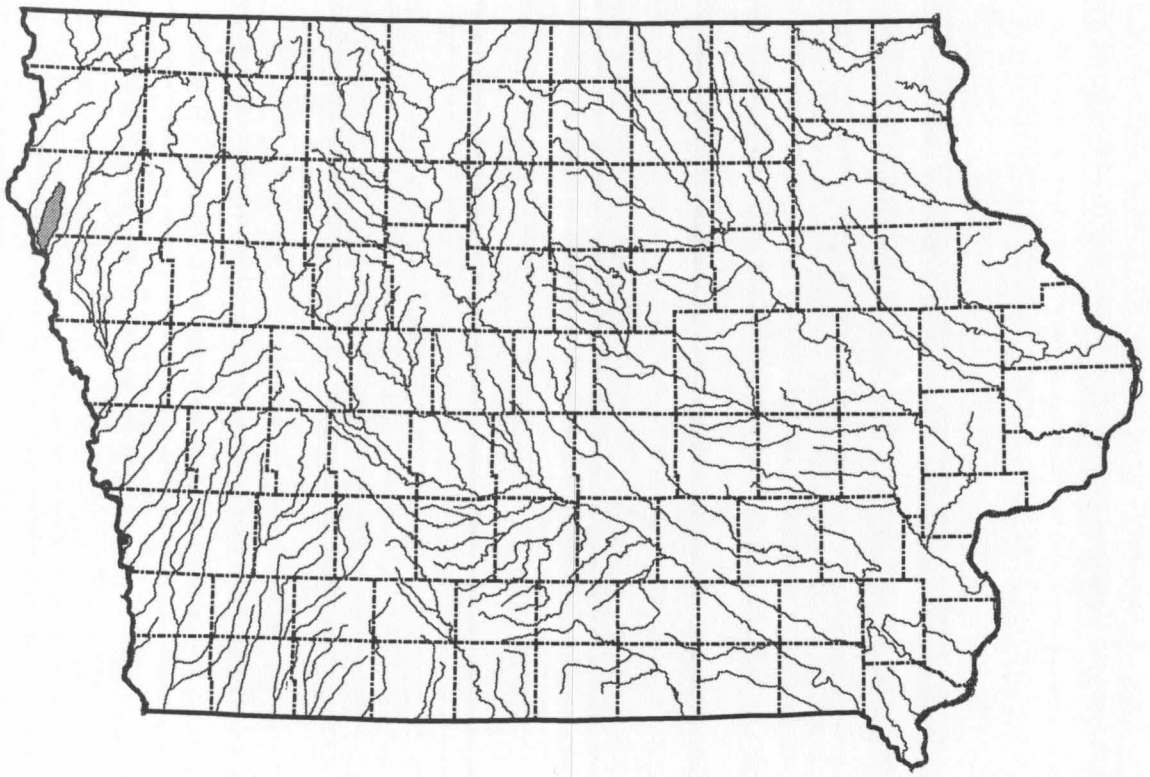
U.S. GEOLOGICAL SURVEY
Open-File Report 96-476



Prepared in cooperation with the

IOWA HIGHWAY RESEARCH BOARD and the PROJECT DEVELOPMENT DIVISION of the IOWA DEPARTMENT OF TRANSPORTATION (IOWA DOT Research Project HR-140)

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By David A. Eash

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Iowa City, Iowa
1996

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Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer

Sea Level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Flood of May 19, 1990, along Perry Creek in Plymouth and Woodbury Counties, Iowa

By David A. Eash

Abstract

A water-surface-elevation profile and peak discharges for the flood of May 19, 1990, along Perry Creek in Plymouth and Woodbury Counties, Iowa, are presented in this report. The peak discharge for the May 19, 1990, flood on Perry Creek at 38th Street, Sioux City (06600000) is the second largest flood-peak discharge recorded at the streamflow-gaging station for the period 1939-95. The peak discharge for May 19, 1990, of 8,670 cubic feet per second, is approximately equal to the 35-year recurrence-interval discharge. The report provides information on flood stages and discharges and floodflow frequencies for streamflow-gaging stations in the Perry Creek Basin using flood information collected during 1939-95. Information on temporary bench marks and reference points established in the Perry Creek Basin during 1990-93 is also included in the report. A flood history describes rainfall conditions for the three largest floods that occurred during 1939-95 (July 1944, September 1949, and May 1990).

INTRODUCTION

Evaluation of flood hazards and the planning, design, and operation of various structures on flood plains require information about floods. Flood reports supply specific information for selected floods and are used by planners and engineers to evaluate the magnitude and frequency of floods in a river basin.

Purpose and Scope

This report presents a water-surface-elevation profile for the flood of May 19, 1990, in the Perry Creek Basin in northwest Iowa. The report provides information on flood stages and discharges and floodflow frequencies for streamflow-gaging stations in the Perry Creek Basin using flood information collected during 1939-95. Information on temporary bench marks and reference points established in the Perry Creek Basin during 1990-93 is also included in the report. A flood history briefly describes rainfall conditions for the three largest known floods that occurred during 1939-95 (July 1944, September 1949, and May 1990).

Acknowledgments

This report was prepared by the U.S. Geological Survey (USGS) in cooperation with the Iowa Highway Research Board and the Project Development Division of the Iowa Department of Transportation. Various Federal, State, and local agencies cooperated in the collection of streamflow records used in this report, the acknowledgment of which is contained in the annual water-data reports of the USGS (U.S. Geological Survey, 1947-96). The author expresses his gratitude to the following: Robert W. Baebenroth, David T. Conell, Alvin R. Conkling, Joseph G. Gorman, Richard L. Kopish, Patrick D. Lustgraaf, Delmer J. O'Connell, and Vincent C. Walczyk for collecting the field data for the 1990 flood and surveying level-lines to establish sea-level elevations for the temporary bench marks; and Trevor L. Birkenholtz and Barbara A. Koppensteiner for preparing the graphics and text for this report.

STUDY AREA

The Perry Creek Basin is located in northwest Iowa, includes parts of Plymouth and Woodbury Counties, and drains as a left-bank tributary to the Missouri River within Sioux City (fig. 1A). The basin is oriented in a general north-south direction and drains 73.3 mi^2 (Larimer, 1957, p. 425). Land use in the basin is primarily agricultural with some urban areas and livestock operations.

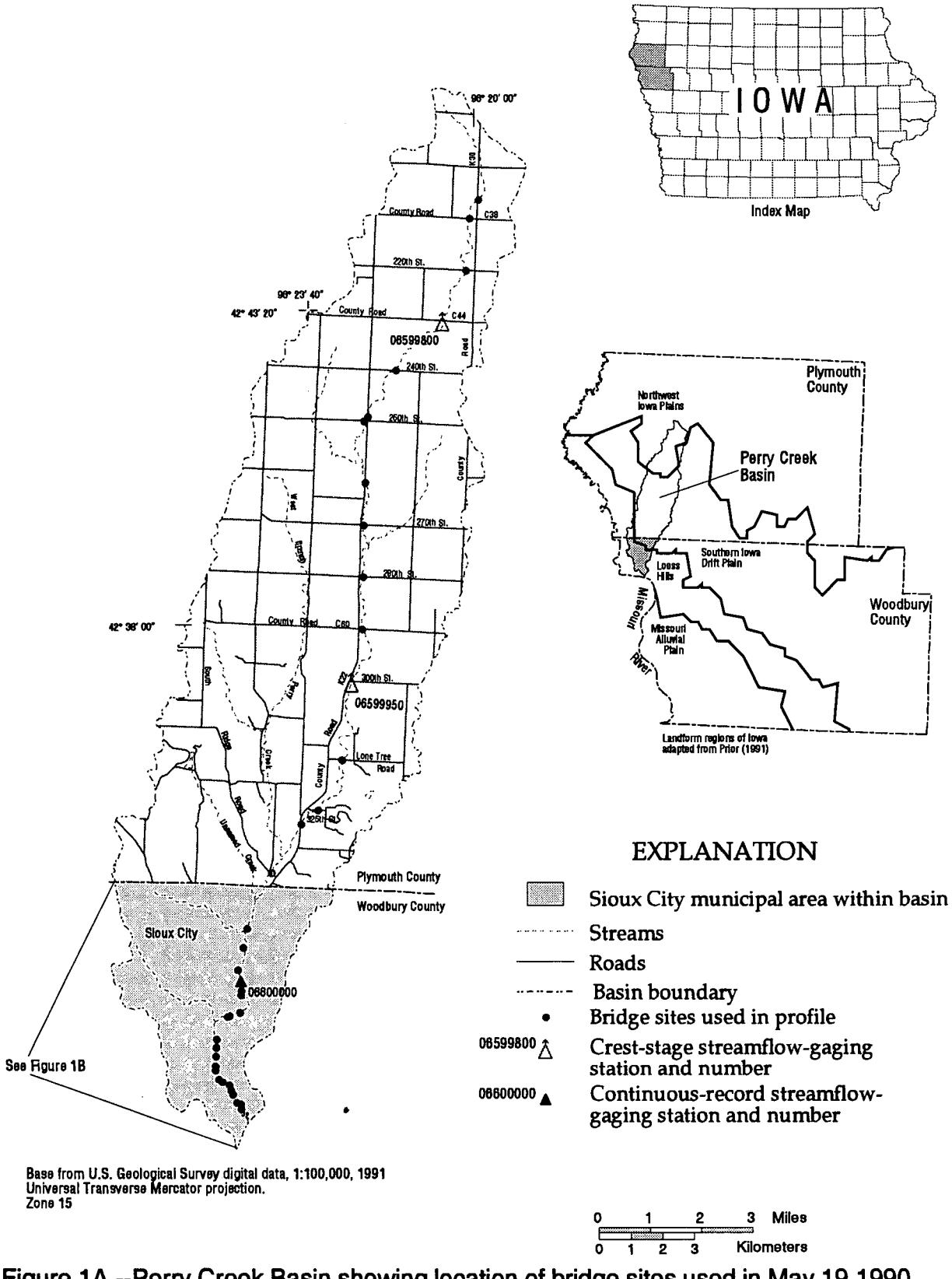

Figure 1A.--Perry Creek Basin showing location of bridge sites used in May 19,1990, flood profile, U.S. Geological Survey streamflow-gaging stations, and roads in Plymouth County.

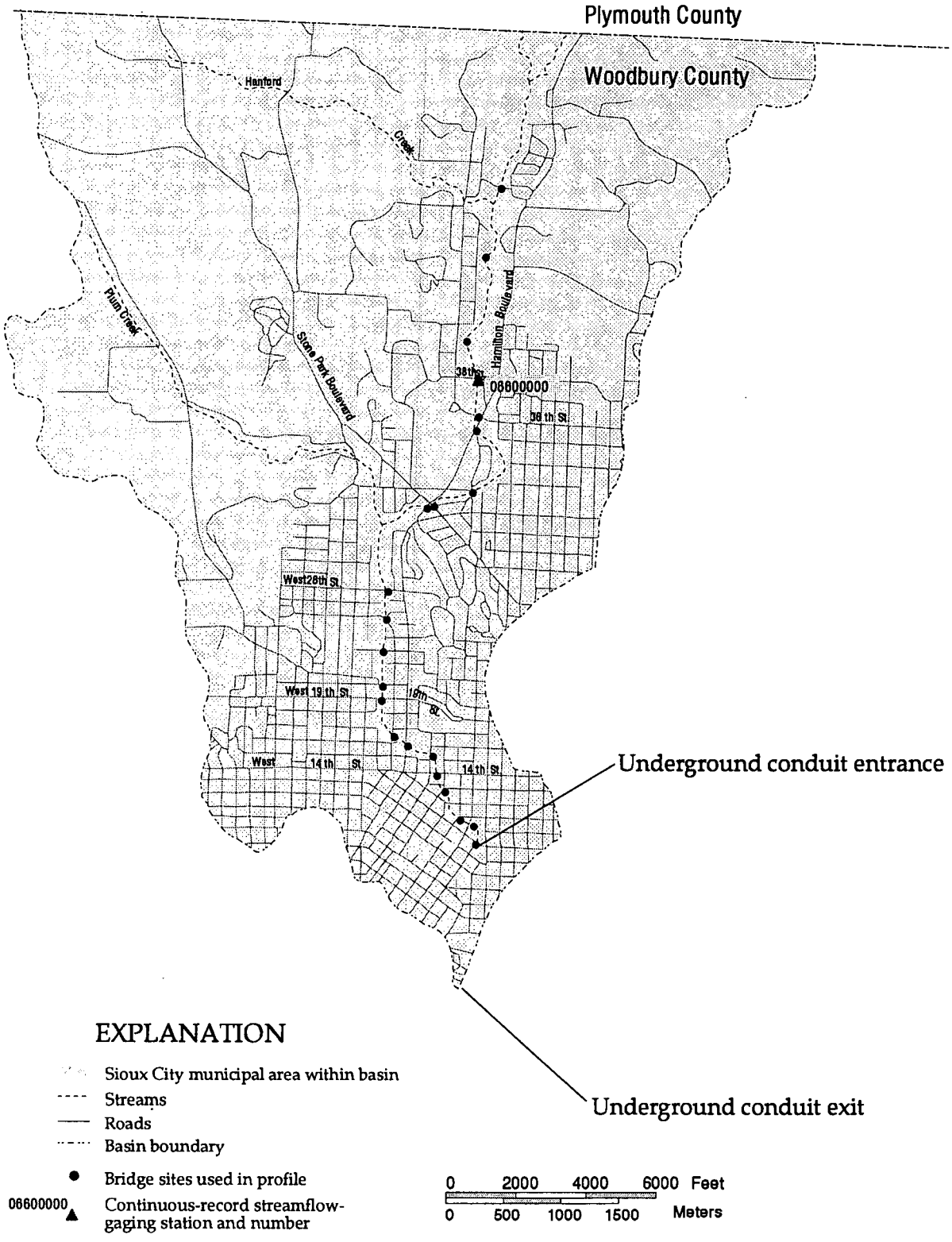

Figure 1B.--Perry Creek Basin showing Sioux City municipal area, location of bridge sites used in May 19, 1990, flood profile, U.S. Geological Survey streamflow-gaging stations, and roads in Sioux City.

The Perry Creek Basin lies within three landform regions of the State: the Northwest Iowa Plains, the Southern Iowa Drift Plain, and the Loess Hills (Prior, 1991, p. 31-34). Drainage networks in northwest Iowa in the vicinity of the Perry Creek Basin are well developed and have high drainage densities, which can produce rapid surface-water runoff. The topography in the vicinity of the Perry Creek Basin is characterized by narrow, gently-sloping ridges and steep side slopes which gradually change to well-defined alluvial valleys (Oschwald and others, 1965, p. 55). Deeply entrenched streams and gullies are common in the alluvial valleys. The topography developed as a result of repeated continental glacial advances across northwest Iowa, during which the land was scoured and thick deposits of glacial till were deposited. Periods of glaciation were followed by interglacial periods of erosion. Nearly all of the upland soils of the area are formed from thick deposits of wind-blown loess that subsequently covered the glacial tills. In general, loess deposits in the vicinity of the Perry Creek Basin are greater than 200 in. (16.7 ft) (Oschwald and others, 1965, p. 6). The loess is thickest on the Missouri River bluffs in Plymouth and Woodbury Counties where it extends in places to depths of 30 ft or more (Iowa Natural Resources Council, 1956, p. 3-5).

In Sioux City, the downstream reach of Perry Creek is confined to an underground concrete conduit for approximately 4,000 ft, extending from the conduit entrance at the Perry Street bridge to its mouth at the Missouri River (Iowa Natural Resources Council, 1956, p. 43). Perry Creek has been straightened in a few reaches through Sioux City upstream of the conduit entrance (fig. 1B).

Mean annual precipitation for 1961-90 at the Sioux City 4 N rain gage, located within the Perry Creek Basin approximately 1 mi north of the Perry Creek at 38th Street, Sioux City streamflow-gaging station (station number 06600000), was 26.98 in. (Owenby and Ezell, 1992, p. 25). The mean annual precipitation at Le Mars, Iowa, (not shown) located approximately 9 mi east of the headwaters of Perry Creek in Plymouth County, was 26.37 in. for the same period (Owenby and Ezell, 1992, p. 24). Mean annual runoff for the periods 1946-69 and 1982-95 in the Perry Creek Basin was 3.77 in. as determined at the Perry Creek at 38th Street, Sioux City gaging station (May and others, 1996, p. 190).

HYDROLOGIC DATA

Gaging-station records are the primary source of data for analyzing and understanding the flood hydrology of a river basin. Flood information is obtained from complete-record streamflow-gaging stations, which provide a continuous chronology of streamflow, and from partial-record, crest-stage streamflow-gaging stations, which provide a chronology of annual peak flows. The location of the three active USGS gaging stations in the Perry Creek Basin, one continuous-record and two crest-stage gaging stations, are shown in figure 1A. The specific location, annual peak stages and discharges, and other information pertaining to each gaging station are presented in Appendix A. Discharge records collected during the operation of these gaging stations are published in the annual water-data reports of the USGS (U.S. Geological Survey, 1947-96).

The computation of discharge records at a gaging station is dependent upon the development of a stage-discharge relation, or rating curve, between water-surface elevations (stages) and the corresponding flow rates (discharges). The high-water part of the stage-discharge relation generally remains stable if the channel downstream from the gaging station remains unchanged. Changes in the stage-discharge relation occur from time to time, either gradually or abruptly, due to changes in the stream channel that result from scour, deposition, or the growth of vegetation (Rantz and others, 1982, p. 328-360).

FLOODFLOW FREQUENCIES

The magnitude and frequency of flood discharges, or floodflow frequencies, for a streamflow-gaging station are determined from a flood-frequency curve which relates observed annual-peak discharges to annual exceedance probability or recurrence interval. Annual exceedance probability is expressed as the chance that a specified flood magnitude will be exceeded in any 1 year. Recurrence interval, which is the reciprocal of the annual exceedance probability, is the statistical average number of years between exceedances of a specified flood magnitude. For example, a flood with a magnitude that is expected to be exceeded on average once during any 100-year period (recurrence interval) has a 1-percent chance (annual exceedance probability = 0.01) of being exceeded dur-

ing any 1 year. This flood, commonly termed the 100-year flood, is the theoretical peak discharge against which actual flood peaks generally are compared. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at shorter intervals or even within the same year.

Floodflow frequencies computed for a gaging station, and recurrence intervals determined for selected flood peaks, are statistics that can change when recalculated as more data become available. Statistics become more reliable as more data are collected and used in the computations. USGS streamflow-gaging stations are the primary source of the streamflow data used in the computations.

A method for determining floodflow frequencies using streamflow-discharge data is outlined in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982, p. 1-28). The Interagency Advisory Committee on Water Data recommends using the Pearson Type-III distribution with log transformation of the data, commonly known as the log-Pearson Type-III distribution, as a base method for determining floodflow frequencies. At least 10 years of gaged annual-peak discharges are required to compute floodflow frequencies using this method. In this report, this method for determining floodflow frequencies is referred to as the "Bulletin 17B" method.

Other methods for determining floodflow frequencies at stream sites in Iowa, including those not gaged, are described by Lara (1987, p. 2-19) and Eash (1993, p. 9-41). Lara (1987) used the physiographic characteristics of Iowa as a guide in defining the boundaries of five hydrologic regions. Regional equations were developed by using the floodflow frequencies for all gaged stations in a hydrologically, homogeneous area, thereby reducing potential errors associated with nonrepresentative, short-term stations. For this reason, a regional analysis might produce improved estimates of the flood characteristics at gaged sites. Two new methods for estimating floodflow frequencies for stream sites in Iowa were developed by Eash (1993). Statewide, drainage-basin equations were developed by relating significant drainage-basin characteristics (quantified using a geographic-information-system procedure) to the floodflow frequencies for 164 streamflow-gaging stations in Iowa. Secondly, statewide and regional channel-geometry equations were developed by relating significant channel-geometry characteristics (measured onsite) to the floodflow frequencies for 157 streamflow-gaging stations in Iowa. Lara (1987) and Eash (1993) both used the Bulletin 17B method as the base method for developing their flood-estimation equations.

The floodflow frequencies computed using the Bulletin 17B method, the regional method of Lara (1987), and the drainage-basin and channel-geometry characteristic methods of Eash (1993) for the gaging stations in the Perry Creek Basin are listed in table 1. The flood-frequency discharges listed in table 1 were determined using available historic flood data and observed annual-peak discharges collected through the following water years: through the 1995 water year for the Bulletin 17B method, through the 1984 water year for the regional method developed by Lara (1987), and through the 1990 water year for the drainage-basin and channel-geometry methods developed by Eash (1993). It should be noted that different flood-frequency discharges might be computed for these gaging stations by other agencies using the Bulletin 17B method if analyses use different periods of record, different approaches to weighting the skewness (asymmetry) of the frequency distribution of the annual peak discharges, or different approaches to incorporation of historical flood information.

FLOOD HISTORY

Continuous records of streamflow have been collected at the USGS streamflow-gaging station on Perry Creek at 38th Street, Sioux City (station number 06600000) from October 1945 to September 1969 and since June 1981. Peak stages listed in Appendix A for the period prior to operation of this gage (1939-43 and 1945), were obtained from wire-weight measurements of gage height made during periods of high flow. Peak stage and discharge information for the 1944 flood were obtained from an indirect measurement made by the U.S. Army Corps of Engineers (USACE). Selected flood-peak discharges, including maximum known flood-peak discharges, and recurrence intervals for the three streamflow-gaging stations in the Perry Creek Basin are listed in table 2.

Twenty-four floods have occurred in the Perry Creek Basin during the period 1892-1990 (USACE, 1990, p. XVII-1--XVII-2). Historic flood information on 22 of these floods occurring from 1892-1978 is documented by the USACE (1980, p. I-9--I-15). The USACE reports (1980, 1990) indicate that all but one

Table 1. *Floodflow frequencies for streamflow-gaging stations in the Perry Creek Basin*

[17B, Bulletin 17B (Interagency Advisory Committee on Water Data, 1982); Lara, regional flood-frequency equations (Hydrologic Region 2; Lara, 1987, p. 28); DB, drainage-basin characteristic flood-frequency equations (Eash, 1993, p. 17); CG, channel-geometry characteristic flood-frequency equations (Region I, active-channel; Eash, 1993, p. 25)]

Station number (fig. 1A)	Station name	Method	Discharge, in cubic feet per second, for indicated recurrence interval, in year					
			2	5	10	25	50	100
06599800	Perry Creek near	17B	240	721	1,240	2,170	3,080	4,170
	Merrill	Lara	649	1,280	1,810	2,550	3,110	3,740
		DB	215	551	880	1,410	1,900	2,460
		CG[a]	356	777	1,150	1,720	2,220	2,770
06599950	Perry Creek near	17B	950	2,470	3,870	6,010	7,830	9,800
	Hinton	Lara	1,440	2,760	3,910	5,430	6,520	7,860
		DB	578	1,390	2,150	3,330	4,390	5,570
		CG[a]	1,190	2,360	3,310	4,690	5,840	7,070
06600000	Perry Creek at	17B	2,470	4,590	6,070	7,930	9,270	10,600
	38th Street,	Lara	2,120	4,000	5,670	7,830	9,330	11,200
	Sioux City	DB	998	2,340	3,560	5,430	7,080	8,900
		CG	1,250	2,460	3,440	4,870	6,060	7,320

[a]Active-channel widths estimated from channel cross sections plotted from field-survey notes.

of these floods were the result of intense rainfall over a portion of the basin; the exception is one flood caused by an ice jam on Perry Creek. Floods on Perry Creek usually occurred with very little advance warning, and the duration of most floods rarely exceeded 12 hours.

Flood of July 7, 1944

The largest flood on record in the Perry Creek Basin occurred on July 7, 1944. During the night of July 6-7, 1944, a frontal system stalled over western Iowa causing excessive rainfall in the lower Floyd River and Perry Creek Basins (U.S. Department of Commerce, Weather Bureau, and Iowa Department of Agriculture, 1944, p. 73-82). Although both streams rose rapidly and flowed overbank, flooding on Perry Creek in Sioux City was particularly severe. Most rainfall was concentrated over a very small area. At the Sioux City airport near Sergeant Bluff in Woodbury County (not shown), located 6 mi south of the mouth of Perry Creek, 1.18 in. of rainfall was recorded. Le Mars (not shown), located approximately 9 mi east of the headwaters of Perry Creek in Plymouth County, recorded 0.8 in. of rainfall; Merrill (not shown), located approximately 5 mi east of the Perry Creek near Merrill crest-stage gage (station number 06599800) in Plymouth County, reported 1.82 in.; and James (not shown), located approximately 4 mi southeast of the Perry Creek near Hinton crest-stage gage (station number 06599950) in Plymouth County, reported 6.98 in. Rainfall of 4.80 in. was reported from within the drainage basin, at a location just north of Grandview Park in Sioux City.

During the 1944 flood on Perry Creek, overbank flow occurred along most of the reach through Sioux City causing the evacuation of hundreds of families. The flooded area in the city was estimated to be about 45 blocks or 3 mi long, from north to south, and from about 1 to 12 to 14 blocks, or as much as 0.75 mi wide, from east to west; and the USGS reported 1,000 acres of land were flooded, and that 1,133 residences and 350 business properties were affected (U.S. Department of Commerce, Weather Bureau, and Iowa Department of Agriculture; 1944; p. 73-82). The USACE (1980, p. I-13) reported many residents were trapped in their

Table 2. *Selected flood-peak discharges, recurrence intervals, and unit runoff for streamflow-gaging stations in the Perry Creek Basin*

[Water year, October 1-September 30; mi^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, cubic foot per second per square mile; *, maximum flood-peak discharge known for station]

Station number (fig. 1A)	Station name and location	Period of flood record (water year)[a]	Drainage area (mi^2)	Date	Gage height (ft)[b]	Discharge (ft^3/s)	Recurrence interval (years)[c]	Unit runoff [$(ft^3/s)/mi^2$]
06599800	Perry Creek near	1953-95	8.17	06-07-53	9.51	*2,540[d]	35	311
	Merrill			03-27-62	12.22[e]	2,000[f]	20	245
				06-14-81	10.15	1,900[f]	20	233
06599950	Perry Creek near	1953-90,	33.1	06-07-53	17.93[g]	4,980[d]	17	150
	Hinton	1995		06-14-81	38.68	*5,500[f]	20	166
				05-19-90	37.90	4,600[f]	14	139
06600000	Perry Creek at	1939-69,	65.1	07-07-44	30.5[h]	*9,600[i]	60	147
	38th Street,	1981-95		09-10-49	26.80[h]	7,780[d]	25	120
	Sioux City			05-19-90	28.54	8,670	35	133

[a]See Appendix A for list of flood peaks.
[b]See Appendix A for datum of gage above sea level.
[c]Interpolated from Bulletin 17B flood-frequency analysis (Interagency Advisory Committee on Water Data, 1982) and rounded to the nearest 5 years for 20- to 50-year recurrence intervals and to the nearest 10 years above the 50-year recurrence interval.
[d]Discharge computed from an indirect measurement made by the U.S. Geological Survey.
[e]Affected by ice.
[f]Approximate.
[g]Prior to 1975, gage at different site and datum.
[h]Referenced to present datum; prior to September 30, 1969, datum was 5.0 ft higher.
[i]Discharge computed from an indirect measurement made by the U.S. Army Corps of Engineers.

homes and were rescued by personnel from the Sioux City Army Air Base, the Police Department, and the Sheriff's Office; the flood inundated 330 city blocks and damaged 914 residences and 222 business establishments; and damages in Sioux City as a result of the flood, including municipal and transportation losses, were estimated at $1,037,000.

At the Perry Creek at 38th Street, Sioux City streamflow-gaging station, the peak discharge (9,600 ft^3/s) and stage (30.5 ft, referenced to present datum) for the flood of July 7, 1944 (table 2), determined from an indirect measurement made by the USACE, are the largest known to have occurred at this site since at least 1938 (1939-95). The flood peak of 9,600 ft^3/s has a recurrence interval of approximately 60 years (table 2). The peak stage associated with this flood exceeded the flood stage by about 6.5 ft at the Perry Creek gage.

Flood of September 10, 1949

The September 10, 1949, flood on Perry Creek was preceded by three storms that occurred in early September in western Iowa (U.S. Department of Commerce, Weather Bureau, and Iowa Department of Agriculture, 1949, p. 156-160). A period of intense thunderstorms with rainfall amounts ranging from 2 to 4 in. in Plymouth and Woodbury Counties during September 2-4, caused minor flooding on Perry Creek in the Sioux City area. Light rains ranging from 0.25 to 0.75 in. fell in western Iowa during September 5-7. Widespread thunderstorms that developed across the State during September 10-12 caused more serious flooding on Perry Creek. Rainfalls of over 5 in. from these thunderstorms were reported from parts of Plymouth County. Rainfall recorded during September 10-11, 1949, in Le Mars (not shown) was 5.66 in., and in the north part of Sioux City amounts ranged from 4.45-4.75 in. The flood of September 10, 1949, inundated 47 city blocks in Sioux City and damaged 184 homes. Total damages as a result of the flood were estimated at $140,300 (USACE, 1980, p. I-14).

At the Perry Creek at 38th Street, Sioux City streamflow-gaging station, the peak discharge (7,780 ft^3/s) for the flood of September 10, 1949 (table 2), determined from an indirect measurement made by the USGS, is the third largest known discharge (1939-95). The flood peak of 7,780 ft^3/s has a recurrence interval of approximately 25 years (table 2).

Flood of May 19, 1990

The majority of the following information pertaining to precipitation for the May 19, 1990, flood was obtained from the National Oceanic and Atmospheric Administration (NOAA, Storm summary report, 1990a; Climatological data, 1990b) and Harry Hillaker (State Climatologist, Iowa Department of Agriculture and Land Stewardship, written commun., 1990). Following a wet spring, persistent and widespread rainfall occurred throughout most of Iowa during May 1990. On average, 5.82 in. of rain fell over the State during May 1990. The rain gage at Perry Creek in Sioux City recorded 12.34 in. during May 1990, which is the maximum amount of rainfall recorded in the State for May 1990.

In early May 1990, antecedent wet soil conditions in the Perry Creek Basin were further saturated when rains fell during May 9-10; rainfall amounts recorded in Le Mars (not shown) were 1.59 in. and at Perry Creek in Sioux City were 1.61 in. Intermittent rains followed during May 12-16, and additional rainfalls of 0.93 and 1.23 in. were recorded in Le Mars and at Perry Creek in Sioux City, respectively. On May 18-19, a large thunderstorm complex developed over western Iowa, Nebraska, and South Dakota. On the morning of May 19th, after more than 4 in. of rain fell over almost the entire Perry Creek Basin, severe flooding occurred along Perry Creek in Plymouth and Woodbury Counties. Rainfalls of 1.32 and 4.55 in. were recorded on May 19th at rain gages in Le Mars and at Perry Creek in Sioux City, respectively. Other reports of rainfall from the storm ranged from 2 to 4 in. in Plymouth County, and from 4 to 5.5 in. in Sioux City, with one report from Sioux City of 8 in.

On the basis of a preliminary "bucket survey" conducted by the USACE (1990, p. E-1--E-5) on May 21, 1990, an isohyetal map was prepared from over 40 rainfall measurements. This isohyetal map indicates that as much as 5 in. of rain fell over a large portion of the central part of the Perry Creek Basin. The average rainfall for the entire basin was determined to have been about 4.6 in. A preliminary analysis conducted by the USACE of depth-duration characteristics for the May 18-19, 1990, storm indicated that total rainfall over the Perry Creek Basin exceeded the 50-year recurrence interval. The peak 1-hour intensity for the storm was determined to be less severe, with a recurrence interval of approximately a 10-year storm event.

Preliminary flood information collected by the USACE (1990, p. E-4) reported that the flood inundated about 86 city blocks. Approximately 68 of these blocks were residential development and the remaining 18 blocks were developed by commercial enterprises. Approximately 750 residential and 100 commercial buildings were located in the flooded area. About 134 residential and 3 commercial buildings were considered to have sustained severe damage. Many residences sustained structural damage; the flood destroyed 17 houses, and structurally damaged 3 bridges (NOAA, Storm summary report, 1990a). Preliminary damage estimates in Sioux City as a result of the flood were reported to be at least $4.5 million (NOAA, Climatological data, 1990b). Damages only for the repair and replacement of public facilities in Sioux City were estimated to be $1.8 million (Don Meisner, Director, Siouxland Interstate Metropolitan Planning Council, written commun., March 1996).

At the Perry Creek at 38th Street, Sioux City streamflow-gaging station, the peak discharge (8,670 ft^3/s) recorded on May 19, 1990 (table 2), is the second largest known discharge (1939-95). The flood peak of 8,670 ft^3/s has a recurrence interval of approximately 35 years (table 2). The peak stage associated with this flood exceeded the flood stage by about 4.5 ft at the Perry Creek gage.

FLOOD PROFILE

The water-surface-elevation profile for the May 19, 1990, flood along Perry Creek in Plymouth and Woodbury Counties, Iowa, is shown in Appendix B (figs. 2-4). Flood elevations located both immediately downstream and 1 bridge-length upstream from selected bridges were identified within a few days of passage of the flood peak and were referenced to a common datum by differential leveling. A low-water profile measured on August 2, 1994, also is shown in figures 2-4 to indicate the approximate low-end of the range of stage that can occur within the profiled reaches. The profiles were defined using data obtained by the USGS. Profiles between the bridges, and between the upstream and downstream sides of individual bridges, are straight-line interpolations which provide only an approximation of the water-surface elevations.

River miles, measured from the most current 1:24,000-scale USGS topographic maps using a geographic-information-system method, are referenced to the mouth of Perry Creek. Measurements of river miles using larger- or smaller-scale cartographic data or different measurement methods may yield different values than those contained in this report. Bridges are designated by an index number that helps to identify their location. For example, 8947-28NW refers to a location in Township 89 North, Range 47 West, northwest quarter of section 28.

Differential leveling was performed to reference all the points along the profiles to a common datum, sea level. A bench mark and a reference point were established at the majority of the bridges in the profiled reach. Bench-mark and reference-point descriptions and elevations are listed in Appendix C.

Bridge-deck and low-bridge-chord elevations are shown in figures 2-4 to indicate the relation between the elevation of important components of the bridges and the elevation of the profiled flood and low-water. For sloping bridges, the profiled bridge-deck and low-bridge-chord elevations represent the lower ends of the bridges.

CONSIDERATIONS

The user of this report is cautioned that the stage-discharge data presented herein are representative of the physical conditions of the basin at the time of the floods described. Changes in the basin can alter the flood magnitude for a specific frequency. Examples of these basin changes include, but are not limited to, extensive urbanization, implementation of agricultural conservation practices, and installation of drainage systems. Changes in the channel conditions immediately downstream from a streamflow-gaging station can substantially affect the stage-discharge relation. Examples of such changes include the construction of dams, bridges, or levees; changes in the flood-plain vegetative cover; straightening of the channel; and natural scour and fill. Temporary changes can be caused by ice and debris jams that produce backwater conditions and can cause the water-surface elevations to plot higher than the normal profile.

SUMMARY

This report provides information on the flood of May 19, 1990, along Perry Creek in Plymouth and Woodbury Counties, Iowa. The peak discharge for the May 19, 1990, flood on Perry Creek at 38th Street, Sioux City is the second largest flood-peak discharge recorded at the streamflow-gaging station for the period 1939-95. The peak discharge for May 19, 1990, of 8,670 ft^3/s, is approximately equal to the 35-year recurrence-interval discharge. The report provides information on flood stages and discharges and flood-flow frequencies for streamflow-gaging stations in the Perry Creek Basin using flood information collected during 1939-95. Information on temporary bench marks and reference points established in the Perry Creek Basin during 1990-93 is also included in the report. A flood history describes rainfall conditions for the three largest floods that occurred during 1939-95 (July 1944, September 1949, and May 1990).

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APPENDIX A

PEAK STAGES AND DISCHARGES FOR STREAMFLOW-GAGING STATIONS IN THE PERRY CREEK BASIN, NORTHWEST IOWA, 1939-95

The peak-stage and discharge data for streamflow-gaging stations located in the Perry Creek Basin were compiled for October 1, 1938, through September 30, 1995. The peak flow data are listed in chronological order. In general, independent peak discharges above a pre-selected base (partial-duration series) are listed for the continuous-record gaging station (Perry Creek at 38th Street, Sioux City). The magnitude of the selected base discharge, given in the "Remarks" section of the headnote, was determined so that it would be equaled or exceeded on the average of about three times per year. Two peak discharges are considered independent if a plot of the recorded stages indicates a well-defined trough between the peaks and if the instantaneous discharge of the trough is 25 percent or more below that of the lower peak (Novak, 1985, p. 93). Only the annual peak discharges are listed for the crest-stage gaging stations.

The peak flow lists for each gaging-station are arranged in downstream order as explained in the annual water-data reports of the USGS (see "References"). The gaging stations are identified by a permanent number that also is used in figure 1 and in tables 1 and 2 of this report. The datum of the gage, when given, is sea level. Flood stage, as determined by the National Weather Service, is the stage at which overflow of the natural banks of the stream begins to cause damage in the reach in which the elevation is measured.

Footnotes used throughout this appendix are selected so that each letter has the same meaning. For example, each occurrence of footnote "b" in any of the lists means "Affected by ice." Not all footnotes may appear in every list.

06599800 Perry Creek near Merrill, Iowa

Location.--Latitude 42°43'16", longitude 96°10'38", in NW1/4, sec. 12, T.91 N., R.47 W., Plymouth County, Hydrologic Unit 10230001, at bridge on County Road C44, 5 mi west of Merrill.

Drainage area.--8.17 mi^2.

Gage.--Crest-stage gage. Datum is 1318.66 ft above sea level (elevation obtained from Plymouth County Engineer). Prior to June 23, 1995, at present site at datum 0.31 ft higher.

Stage-discharge relation.--Defined by current-meter measurements, step-backwater computations, and an indirect measurement.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1953	June 7, 1953	9.51	2,540[a]
1954	June 19, 1954	5.84	169
1955	May 26, 1955	3.60	37.0
1956	Mar. 1, 1956	4.10	54.0
1957	May 11, 1957	5.66	151
1958	May 31, 1958	8.73	857
1959	May 30, 1959	8.81	932
1960	June 20, 1960	5.02	69.0
1961	Mar. 26, 1961	7.44	428
1962	Mar. 27, 1962	12.22[b]	2,000[c]
1963	--	--[d]	20.0[e]
1964	July 10, 1964	7.09	358
1965	Mar. 31, 1965	9.39[b]	300[c]
1966	Feb. 9, 1966	8.68[b]	--
1967	Mar. 2, 1967	10.80[b]	--
1968	--	--[d]	20.0[e]
1969	June 25, 1969	8.21	620
1970	--	--[d]	20.0[e]
1971	Feb. 18, 1971	9.52[b]	145[c]
1972	July 20, 1972	8.92	950
1973	July 9, 1973	7.66	330
1974	June 22, 1974	4.77	45[c]
1975	Mar. 19, 1975	7.89[b]	--
	June 18, 1975	5.24	50[c]

06599800 Perry Creek near Merrill, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1976	--	--[d]	20.0[e]
1977	June 23, 1977	9.38	790[f]
1978	Mar. 19, 1978	8.87[b]	--
1979	May 9, 1979	5.16	54[c]
1980	May 30, 1980	4.96	48[c]
1981	June 14, 1981	10.15	1,900[c]
1982	July 6, 1982	9.89	1,400[c]
1983	June 20, 1983	9.62	990[c]
1984	June 12, 1984	8.93	500[c]
1985	Apr. 23, 1985	--	--
1986	Mar. 17, 1986	6.73	140[c]
1987	May 25, 1987	6.29	110[c]
1988	Feb. 18, 1988	6.20[b]	--
1989	Mar. 9, 1989	7.19	170[c]
1990	May 19, 1990	9.72	1,100[c]
1991	June 1, 1991	8.55[g]	360[c]
1992	July 10, 1992	7.91	240[f]
1993	Mar. 8, 1993	9.03	560[c,f]
1994	Feb. 18, 1994	6.46	120[c]
1995[h]	Mar. 11, 1995	6.40	110[c]

(Bridge replaced, gage removed June 23, 1995. Gage reinstalled on new bridge Mar. 15, 1996, at new datum.)

[a]Discharge computed from indirect measurement made by U.S. Geological Survey.
[b]Affected by ice.
[c]Approximate.
[d]Peak stage did not reach bottom of gage.
[e]Discharge less than indicated value.
[f]Discharge revised from previously published value.
[g]Gage height revised from previously published value.
[h]Peak for 1995 is from October 1 to June 23.

06599950 Perry Creek near Hinton, Iowa

Location.--Latitude 42°37'57", longitude 96°22'13", in NE1/4, sec 15, T.90 N., R.47 W., Plymouth County, Hydrologic Unit 10230001, at bridge on 300th Street, 4 mi west of Hinton. Prior to1975 at site about 1 mi upstream at drainage area of 30.8 mi^2.

Drainage area.-- 33.1 mi^2.

Gage.--Crest-stage gage. Datum is 1190.19 ft above sea level (elevation obtained from Plymouth County Engineer). Prior to Aug. 28, 1974, at different site and datum. From Aug. 28, 1974, to May19, 1990, at present site at datum about 6.7 ft lower.

Stage-discharge relation.--Defined by current-meter measurements, step-backwater computations, and indirect measurements.

Remarks.--Only annual peaks are shown.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1953	June 7, 1953	17.93	4,980[a]
1954	June 19, 1954	14.44	1,660[a]
1955	May 26, 1955	8.93	350
1956	--	--	--
1957	July 8, 1957	10.76	655
1958	May 31, 1958	15.50	2,350
1959	May 30, 1959	16.32	3,000
1960	Aug. 28, 1960	9.96	520
1961	Mar. 14, 1961	7.44	180
1962	Mar. 27, 1962	17.05	3,800
1963	June 4, 1963	8.56	305
1964	May 5, 1964	9.89	485
1965	Mar. 31, 1965	11.01[b]	600[c]
1966	Feb. 9, 1966	16.01[b]	--
1967	May 10, 1967	12.58	1,070
1968	--	--[d]	156[e]
1969	June 25, 1969	12.15	940
1970	--	--[d]	156[e]
1971	--	--[d]	156[e]
1972	--	--[d]	156[e]
1973	--	--[d]	156[e]
1974	--	--[d]	156[e]

06599950 Perry Creek near Hinton, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
(Gage moved to new site and datum on August 28, 1974.)			
1975	June 18, 1975	26.77	338
1976	Feb. 17, 1976	28.67[b]	--
1977	June 23, 1977	34.70	2,410
1978	Mar. 19, 1978	33.27[b]	--
1979	Mar. 22, 1979	30.93	1,180
1980	May 30, 1980	30.08	964
1981	June 14, 1981	38.68	5,500[c]
1982	Feb. 23, 1982	34.48[b]	--
1983	June 20, 1983	32.61	1,670
1984	June 20, 1984	36.77	3,490
1985	Apr. 23, 1985	35.86	2,900
1986	Mar. 17, 1986	32.81	1,740
1987	--	--	--
1988	--	--	--
1989	July 17, 1989	36.65	3,700[a]
1990	May 19, 1990	37.90	4,600[c]
(Bridge and gage damaged by May 1990 flood. Gage reinstalled on new bridge July 22, 1994, at new datum.)			
1995	May 28, 1995	24.73	--

[a]Discharge computed from indirect measurement made by U.S. Geological Survey.
[b]Affected by ice.
[c]Approximate.
[d]Peak stage did not reach bottom of gage.
[e]Discharge less than indicated value.

06600000 Perry Creek at 38th Street, Sioux City, Iowa

Location.--Latitude 42°32'08", longitude 96°24'39", in SE1/4, sec. 8, T.89 N., R.47 W., Woodbury County, Hydrologic Unit 10230001, on left bank at downstream side of bridge on 38th Street in Sioux City, 3.3 mi downstream from West Branch, and 4.2 mi upstream from mouth.

Drainage area.-- 65.1 mi^2.

Gage.--Water-stage encoder. Datum is 1,112.04 ft above sea level (City of Sioux City benchmark). Prior to May 20, 1954, nonrecording gage with supplementary water-stage recorder in operation above 5.0 ft gage height and May 20, 1954, to Sept. 30, 1969, water-stage recorder at present site at datum 5.0 ft higher.

Stage-discharge relation.--Defined by current-meter and indirect measurements.

Flood stage.--24 ft.

Remarks.--Base for partial-duration series, 800 ft^3/s.

Peak stages and discharges

[Water year, October 1-September 30; ft, feet above gage datum; ft^3/s, cubic feet per second; --, not determined]

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1939	May 27, 1939	11.33[i]	3,950
1940	June 4, 1940	12.30[i]	4,680
1941	Sept. 15, 1941	9.05[i]	2,340
1942	June 19, 1942	5.40[i]	718
1943	July 20, 1943	6.35[i]	775
1944	July 7, 1944	25.5[j]	9,600[k]
1945	June 26, 1945	8.10[i]	2,020
1946	Feb. 6, 1946	8.44[b]	900[c]
	May 18, 1946	8.05	1,070
	May 23, 1946	7.85	1,020
	Sept. 8, 1946	7.82	1,020
1947	June 22, 1947	4.42	246
1948	Feb. 16, 1948	7.53	935
	Feb. 17, 1948	7.30	881
	Feb. 27, 1948	9.34	1,470
	June 22, 1948	10.40	1,840
	July 29, 1948	9.54	1,540
	Aug. 14, 1948	14.12	3,350

06600000 Perry Creek at 38th Street, Sioux City, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1949	Mar. 4, 1949	7.77	900
	Mar. 24, 1949	7.11	827
	July 27, 1949	12.32	2,570
	Aug. 13, 1949	17.28	5,080
	Sept. 3, 1949	19.85	6,580
	Sept. 10, 1949	21.80	7,780[a]
1950	Mar. 4, 1950	10.5[b]	1,600[c]
	June 17, 1950	12.47	2,650
	July 12, 1950	17.75	5,380
	July 21, 1950	8.7	1,280
	Aug. 7, 1950	9.42	1,500
	Aug. 11, 1950	9.00	1,370
1951	Mar. 25, 1951	7.62	962
	Mar. 27, 1951	10.97	2,050
	June 19, 1951	17.38	5,480
	Aug. 12, 1951	7.53	1,340
	Aug. 14, 1951	5.96	844
	Aug. 17, 1951	6.75	1,110
	Aug. 20, 1951	6.43	984
	Aug. 27, 1951	7.54	1,340
	Sept. 9, 1951	10.21	2,310
1952	Jan. 19, 1952	7.75	1,430
	Mar. 12, 1952	8.33	1,620
	Mar. 30, 1952	7.08	1,200
	June 8, 1952	8.32	1,610
	July 7, 1952	17.40	5,480
1953	June 7, 1953	12.56	3,470
1954	May 26, 1954	5.55	1,080
	May 31, 1954	6.30	1,300
	June 2, 1954	4.97	881
	June 19, 1954	13.75	4,010
1955	May 26, 1955	6.98	1,580
	July 9, 1955	15.40	4,880
1956	Aug. 4, 1956	4.88	865
	Aug. 18, 1956	9.42	2,440
1957	June 22, 1957	6.20	1,320
	July 8, 1957	7.90	1,920

06600000 Perry Creek at 38th Street, Sioux City, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1958	May 31, 1958	8.89	1,540
1959	May 30, 1959	12.14	2,660
1960	Mar. 29, 1960	10.70	2,140
	Apr. 1, 1960	13.05	3,020
	July 12, 1960	7.32	1,120
	Aug. 5, 1960	6.22	836
	Aug. 28, 1960	12.16	2,700
1961	Mar. 14, 1961	5.43	864
	June 14, 1961	13.20	3,540
	July 26, 1961	8.85	1,880
1962	Mar. 27, 1962	13.27	3,580
	June 7, 1962	10.50	2,480
	June 10, 1962	6.46	1,050
	July 27, 1962	8.40	1,750
1963	June 2, 1963	13.60	3,710
	June 5, 1963	6.65	1,200
1964	May 5, 1964	4.95	760
1965	Mar. 31, 1965	5.59	913
1966	Feb. 8, 1966	13.00	3,460
1967	May 10, 1967	11.70	2,940
	June 7, 1967	6.69	1,230
	June 10, 1967	10.47	2,470
	June 13, 1967	6.59	1,200
	June 17, 1967	6.88	1,280
	June 19, 1967	10.75	2,570
1968	July 17, 1968	3.49	408
1969	Apr. 1, 1969	6.70	1,230
	Apr. 4, 1969	8.15	1,670
	June 25, 1969	11.02	2,430
(Gage discontinued September 30, 1969, reactivated June1981 at present site at new datum.)			
1981[i]	June 28, 1981	11.76	1,210
	June 29, 1981	13.00	1,580
	July 3, 1981	13.99	1,910
1982	Feb. 23, 1982	14.60[j]	2,120
1983	June 20, 1983	13.87	1,870
	June 27, 1983	12.88	1,540
	July 23, 1983	11.35	1,090

06600000 Perry Creek at 38th Street, Sioux City, Iowa

Peak stages and discharges--Continued

Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1984	June 12, 1984	12.45	1,160
	June 20, 1984	18.16	3,500
	June 21, 1984	16.63	2,310
1985	Mar. 4, 1985	13.26	1,470
	Apr. 22, 1985	13.28	1,470
	Apr. 23, 1985	19.20	3,940
1986	Mar. 12, 1986	12.96	1,370
	Mar. 17, 1986	15.96	2,440
	June 29, 1986	13.49	1,540
	Sept. 20, 1986	14.82	2,000
1987	May 25, 1987	11.94	1,060
1988	Feb. 18, 1988	10.41[b]	351
1989	Mar. 9, 1989	13.73	1,660
	July 18, 1989	17.93	3,390
	July 29, 1989	11.12	825
	Sept. 7, 1989	12.97	1,390
1990	May 19, 1990	28.54	8,670
	May 23, 1990	26.02	4,770
	July 19, 1990	17.76	3,310
1991	June 1, 1991	17.88	3,360
	June 15, 1991	14.43	1,920
1992	June 17, 1992	12.38	1,200
	July 8, 1992	11.50	930
	July 10, 1992	11.94	1,060
1993	Mar. 7, 1993	11.38	896
	Mar. 8, 1993	12.14	1,120
1994	Feb. 18, 1994	16.92	2,810
	June 18, 1994	14.78	2,010
1995	May 28, 1995	12.65	1,300

[a]Discharge computed from indirect measurement made by U.S. Geological Survey.
[b]Affected by ice.
[c]Approximate.
[i]Peak stage obtained by U.S. Geological Survey from wire-weight measurements of gage height made during periods of high flow prior to operation of continuous-record gage.
[j]Gage height determined from floodmarks.
[k]Discharge computed from indirect measurement made by U.S. Army Corps of Engineers.
[l]Peaks for 1981 are from June 20 to September 30.

APPENDIX B

WATER-SURFACE-ELEVATION PROFILES FOR PERRY CREEK

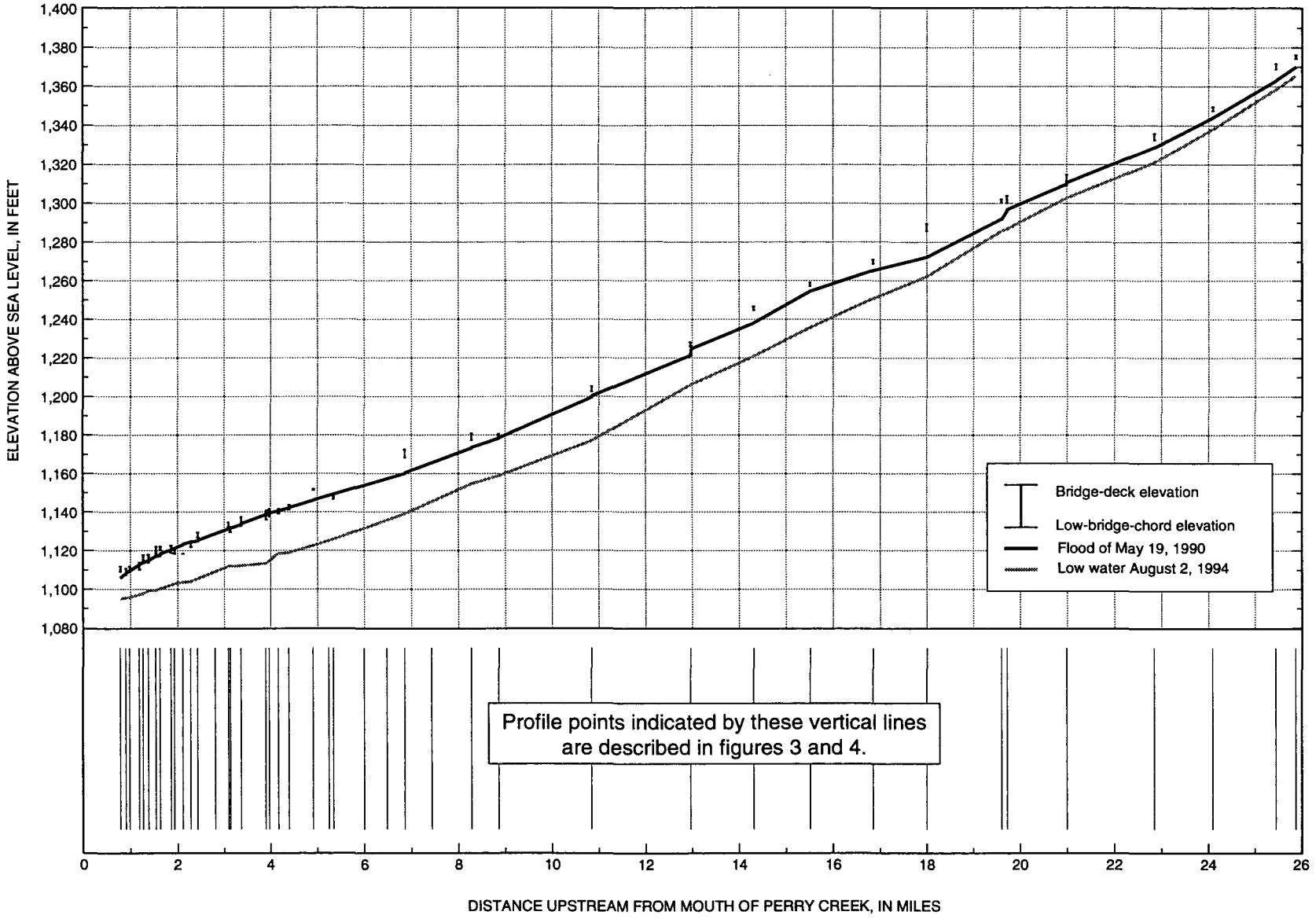

Figure 2. Water-surface-elevation profiles for Perry Creek, river miles 0-25.88.

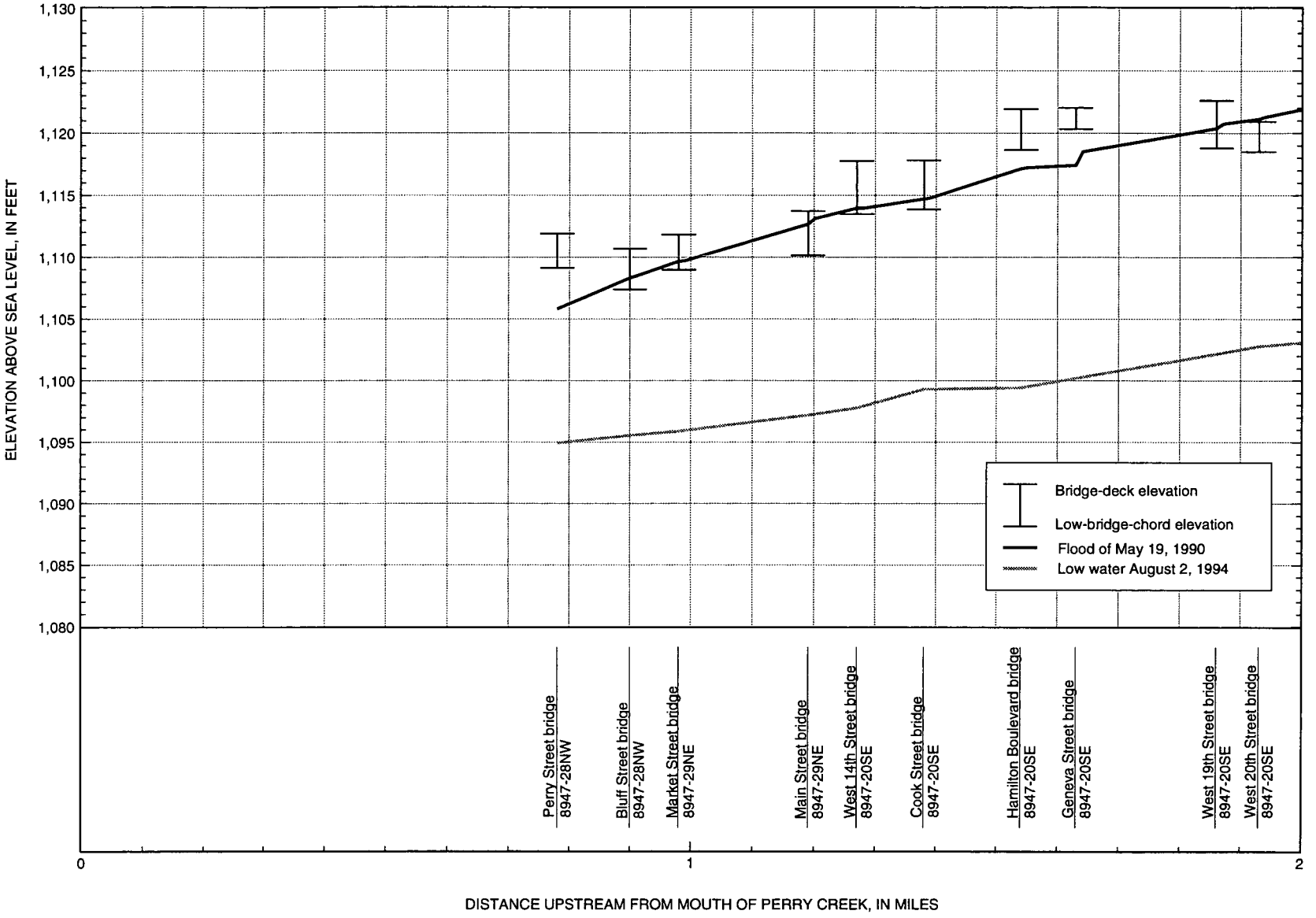

Figure 3A. Water-surface-elevation profiles for Perry Creek, river miles 0-2.

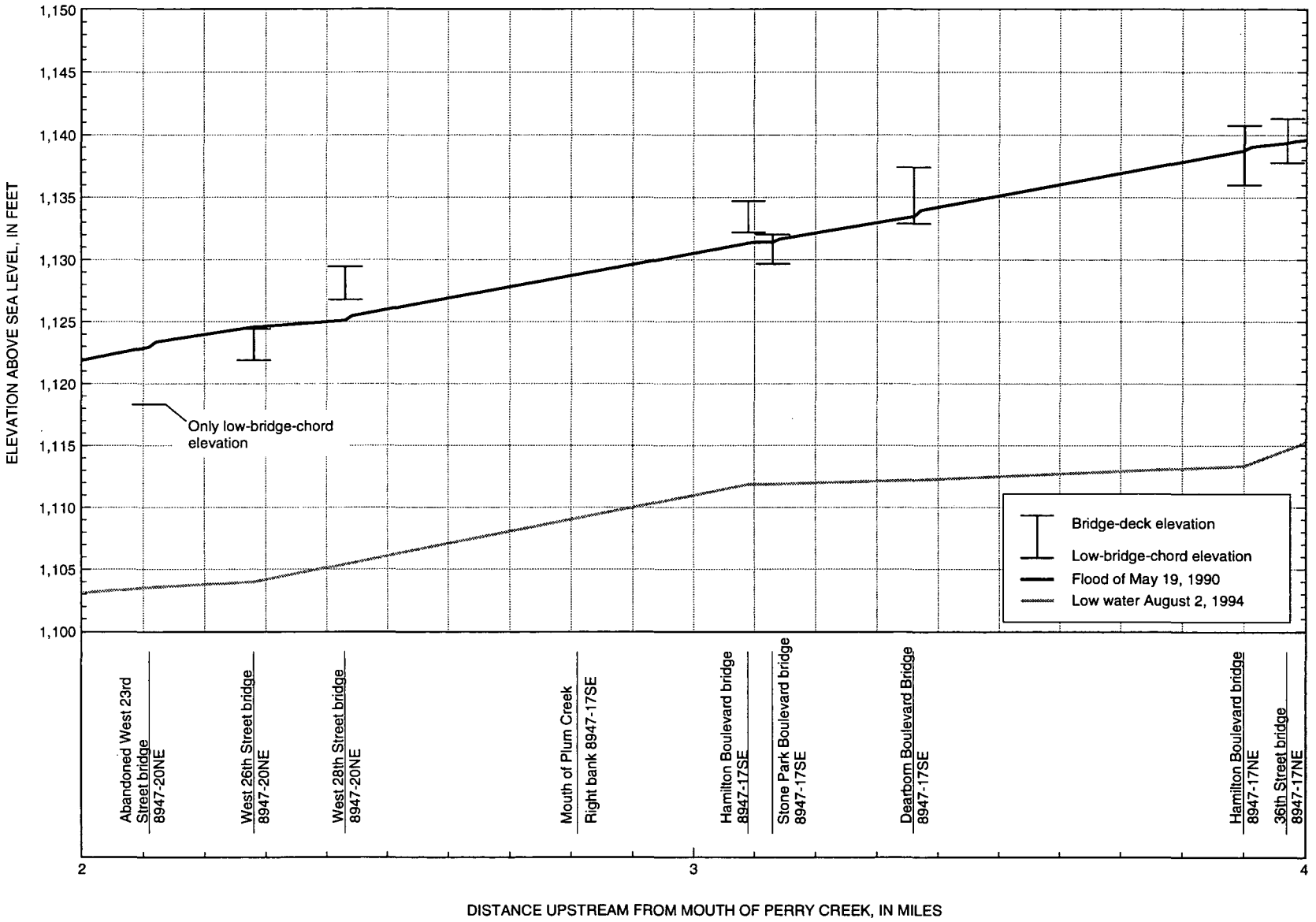

Figure 3B. Water-surface-elevation profiles for Perry Creek, river miles 2-4.

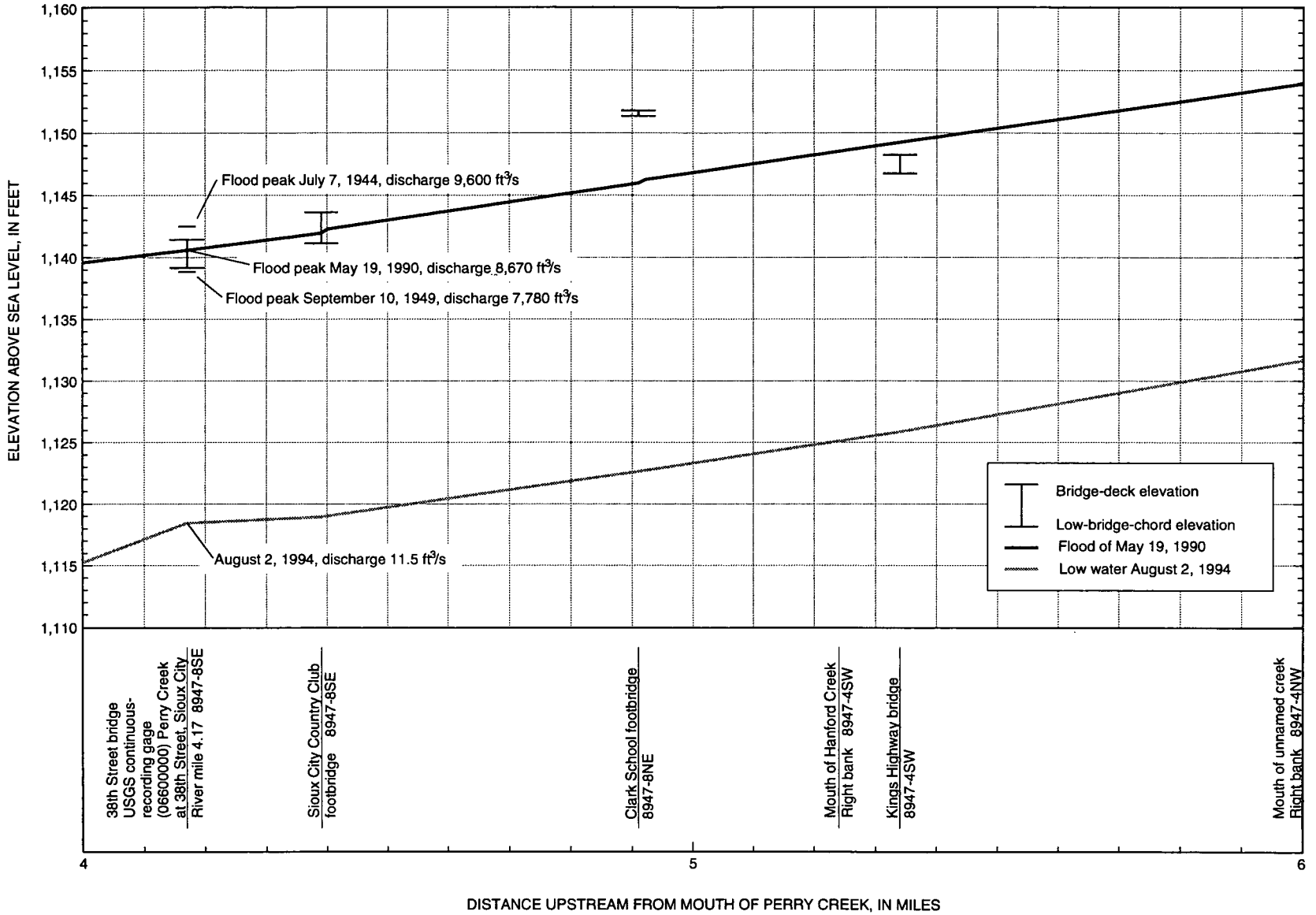

Figure 3C. Water-surface-elevation profiles for Perry Creek, river miles 4-6.

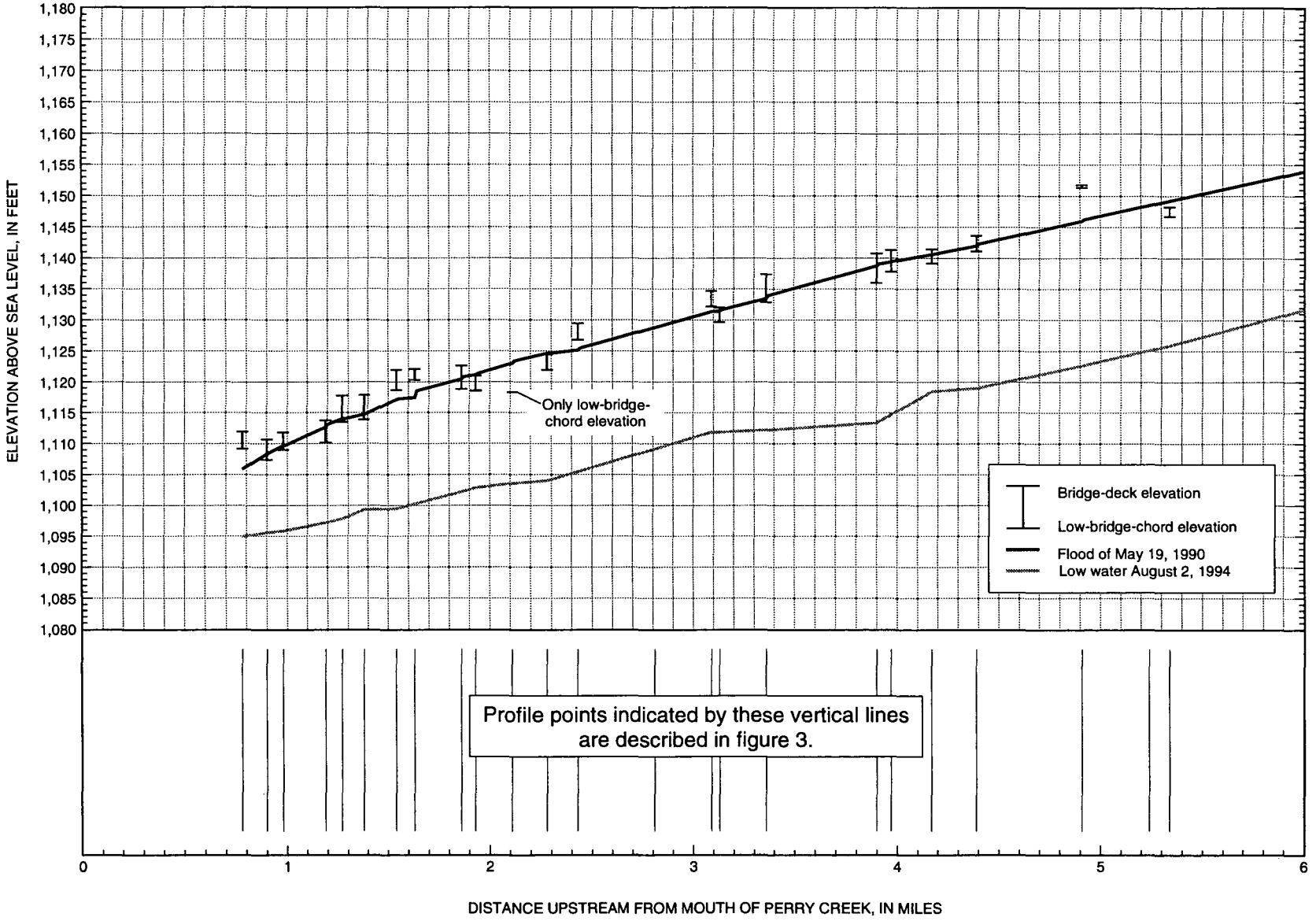

Figure 4A. Water-surface-elevation profiles for Perry Creek, river miles 0-6.

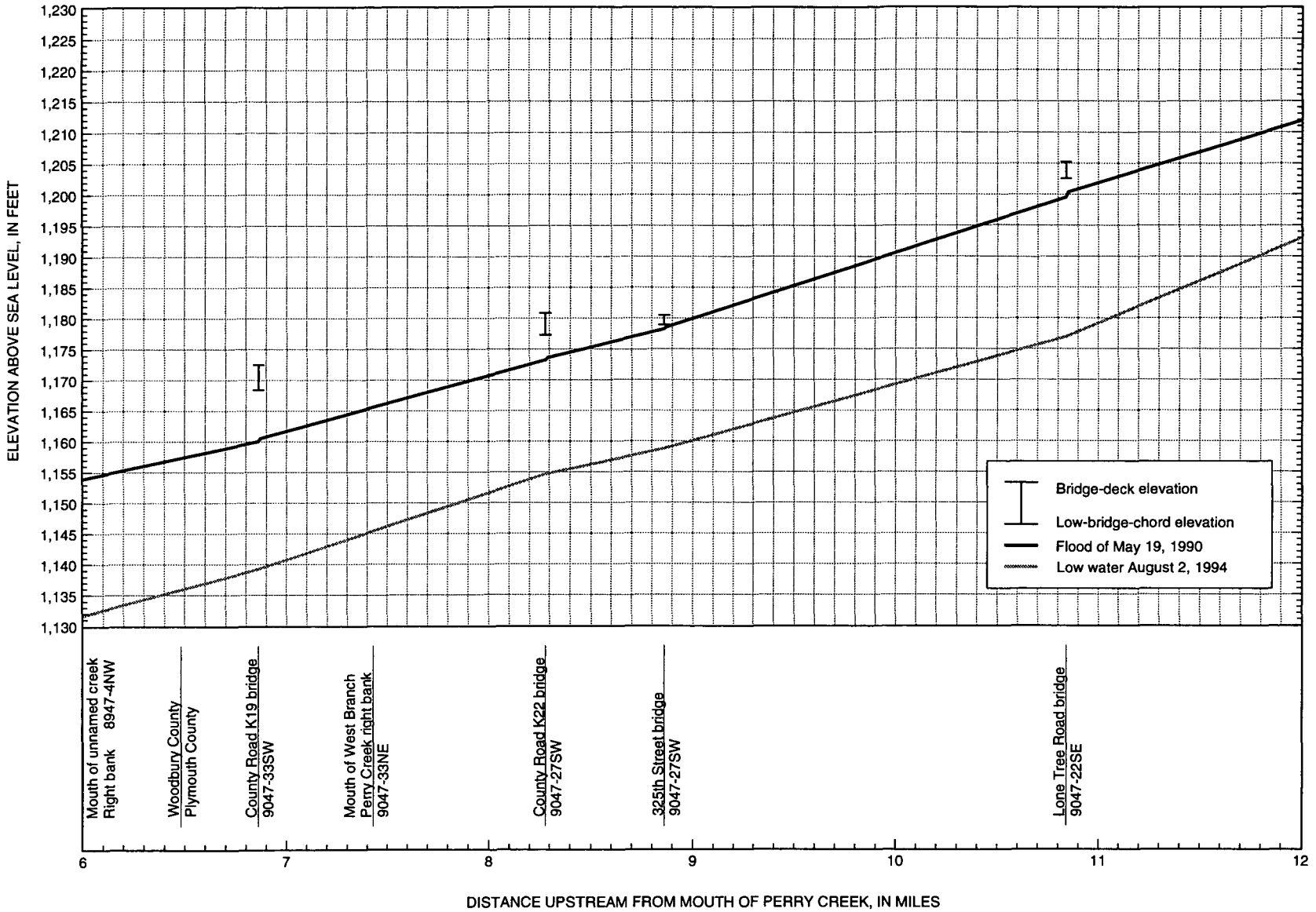

Figure 4B. Water-surface-elevation profiles for Perry Creek, river miles 6-12.

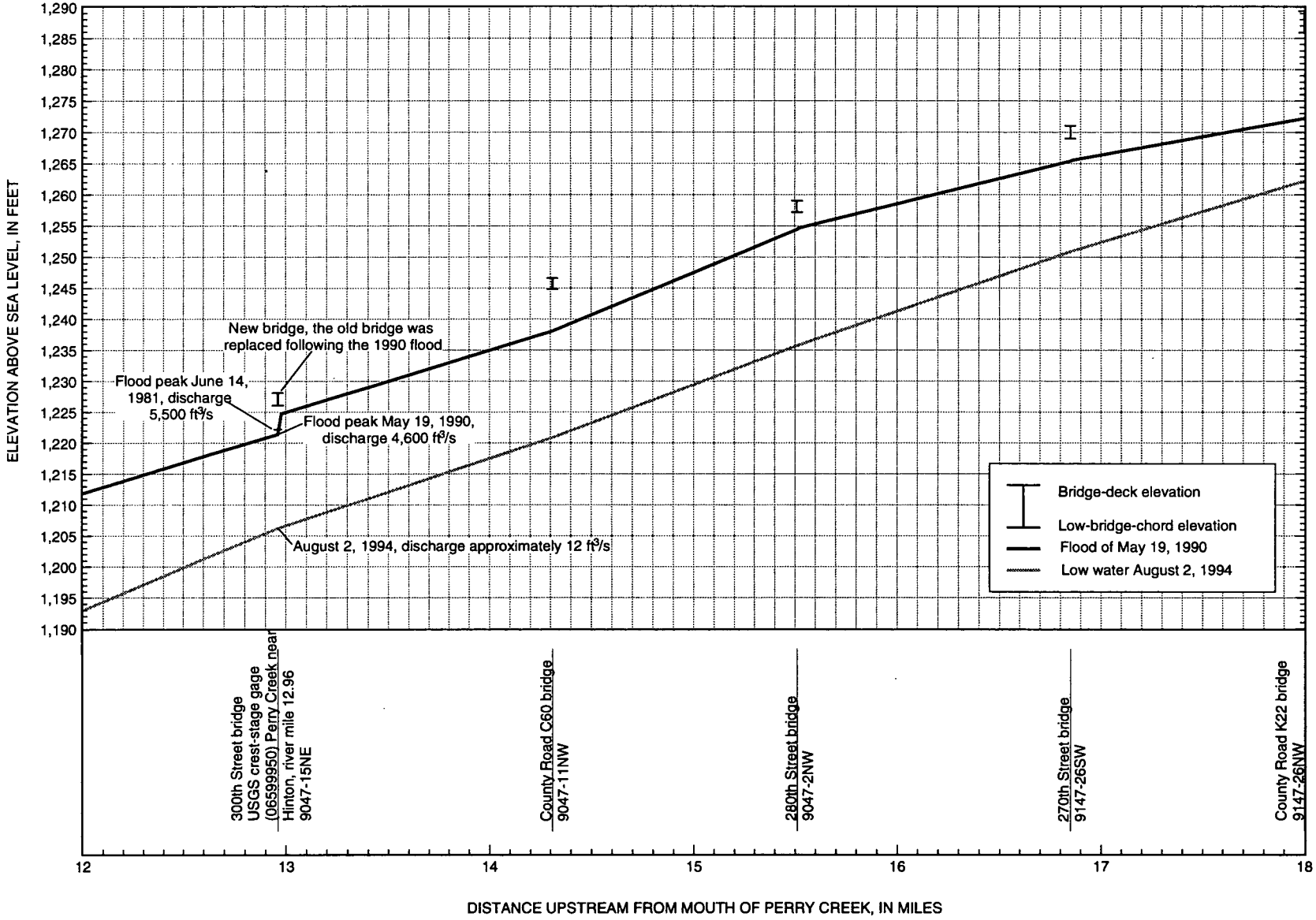

Figure 4C. Water-surface-elevation profiles for Perry Creek, river miles 12-18.

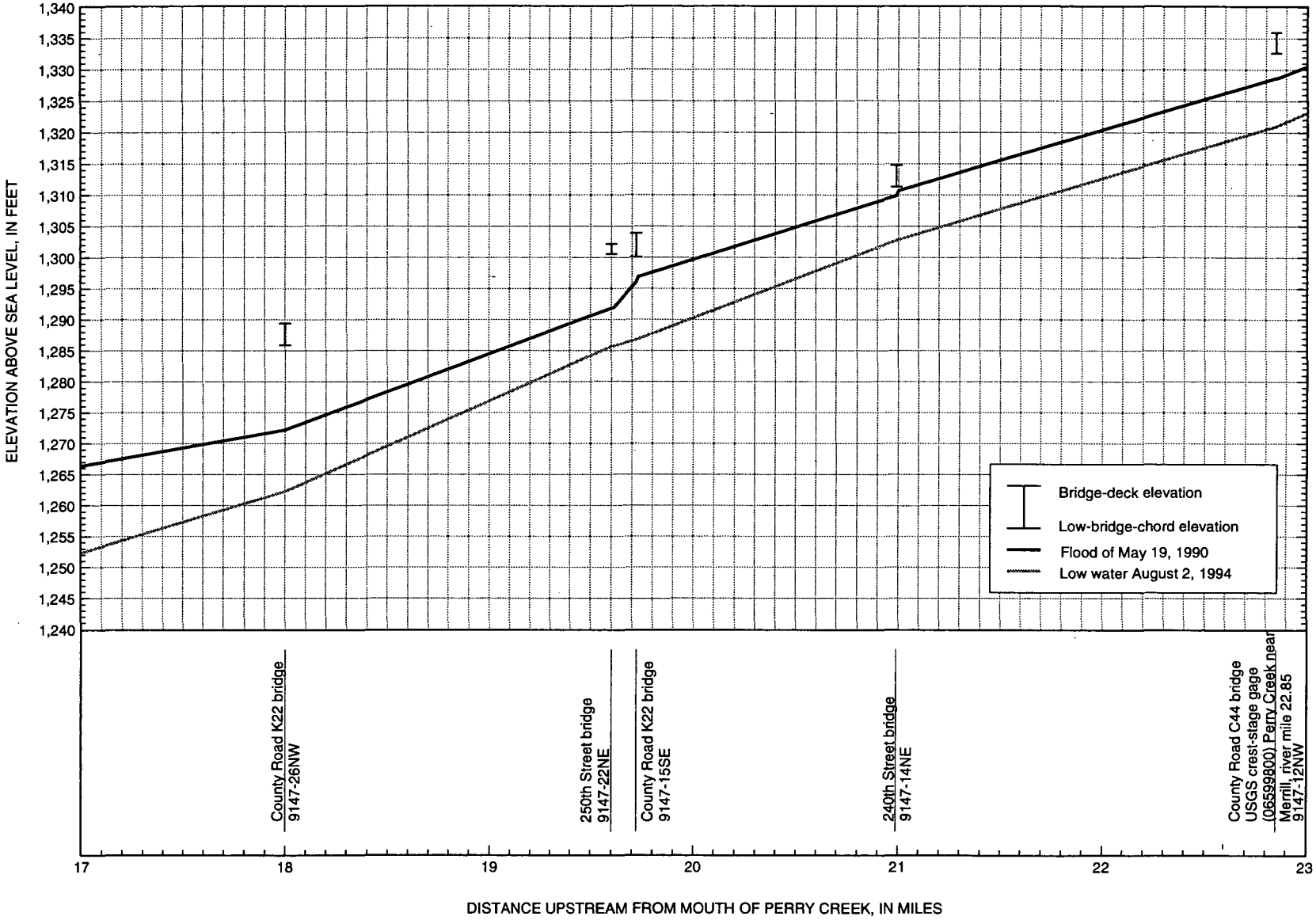

Figure 4D. Water-surface-elevation profiles for Perry Creek, river miles 17-23.

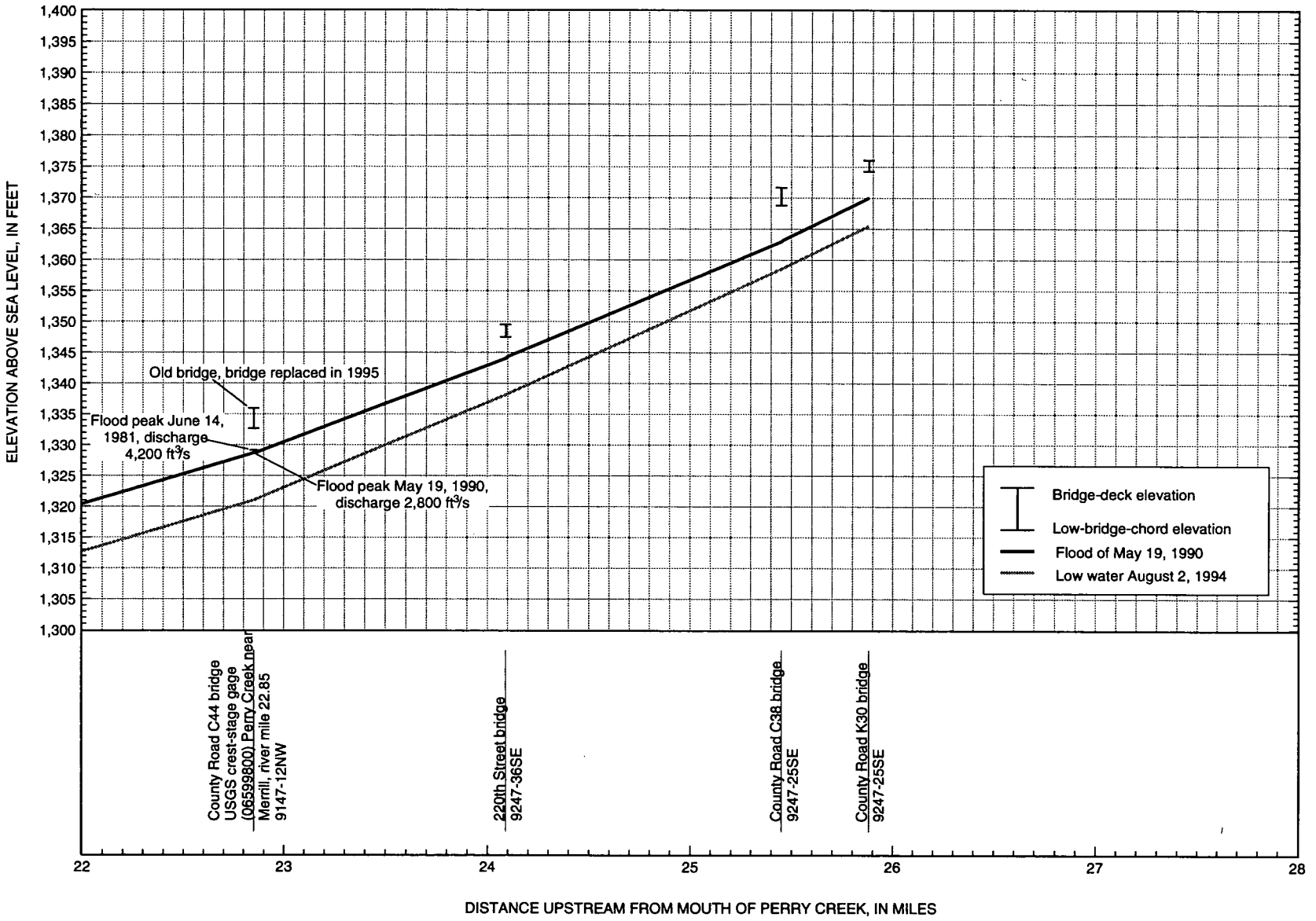

Figure 4E. Water-surface-elevation profiles for Perry Creek, river miles 22-25.88.

APPENDIX C

TEMPORARY BENCH MARKS AND REFERENCE POINTS IN THE PERRY CREEK BASIN, NORTHWEST IOWA

The temporary bench marks (BM) and reference points (RP) listed in this tabulation were established during 1990-93 by the U.S. Geological Survey (USGS) except those for which credit is given in the descriptions. The work was done as a part of a stream-profile study jointly funded by the Iowa Highway Research Board and the Project Development Division of the Iowa Department of Transportation, and the USGS.

Differential leveling was performed along Perry Creek from the County Road K30 bridge, northwest of Merrill in Plymouth County, to the Perry Street bridge at the entrance of the underground concrete conduit in Sioux City (figs. 1-4). BMs and RPs were set at the majority of bridges crossing Perry Creek along this reach. Level lines to establish the third-order accuracy of the BMs and RPs shown herein were surveyed from bench marks established by Plymouth County and the City of Sioux City. Errors of closure in the USGS level work were adjusted along the level lines to balance the BM and RP elevations. All elevations are referenced to sea level.

The BMs and RPs are identified by an index number, which is composed of the township, range, and section number, and the quarter section in which the BM or RP is located. The township and range numbers are combined into a four-digit number, such as 8947 for Township 89 North and Range 47 West. The township and range number is followed by a dash and the section number in which the BM or RP is located. Within the section, the quarter in which the BM or RP is located is designated by NE, SE, SW, and NW. A number in parentheses following this letter designation indicates the number of the BM or RP in that particular quarter section. The index number serves to describe the landline location of the BM or RP without further reference in the body of the description.

Standard BMs and RPs such as chiseled squares on concrete, filed marks on steel, bolts driven horizontally in wood, or existing bolts on bridges were used. BMs and RPs also were established on the extreme corners of horizontal surfaces on bridges, such as a wingwall, bridgerail, or guardrail post. Existing marks were used wherever available, and the agency responsible for the mark, when known, is indicated in the description. RPs are distinguished from BMs in this tabulation by the notation "(REFERENCE POINT)" following the index number. RPs were established to permit water-surface elevations to be determined by use of a tape and weight. The terms "right" and "left" in the descriptions are determined as viewed while facing in the direction of the flow of the stream.

The user of this information is cautioned that the BMs and RPs listed herein might have been disturbed, destroyed, or moved since surveys used in this report were made. Many of the BMs and RPs are located on bridges that might have been repaired, replaced, or destroyed since the original level lines were surveyed. It is the responsibility of the user to determine the condition and the suitability of the BM or RP.

Additional information can be obtained by writing to the following address: U.S. Geological Survey, Water Resources Division, RM. 269, Federal Building, 400 South Clinton Street, Iowa City, IA 52244.

TEMPORARY BENCH MARKS AND REFERENCE POINTS IN THE PERRY CREEK BASIN, NORTHWEST IOWA

8947-04 SW (1)-- At Sioux City, on Kings Highway bridge over Perry Creek, on right downstream bridge abutment; extreme right downstream corner of abutment.

Elevation 1148.48 ft.

8947-04 SW (2)--(REFERENCE POINT) At Sioux City, on Kings Highway bridge over Perry Creek, on downstream bridgerail, 40 ft streamward from bench mark 8947-04 SW (1); three filed marks.

Elevation 1151.30 ft.

8947-08 NE (1)-- At Sioux City, on Clark School footbridge over Perry Creek, on right upstream bridge abutment, on top of horizontal I-beam support; extreme upstream streamward corner of I-beam support.

Elevation 1151.41 ft.

8947-08 NE (2)--(REFERENCE POINT) At Sioux City, on Clark School footbridge over Perry Creek, on walkway near center of footbridge, at fifth vertical support of walkway fence; two filed marks.

Elevation 1151.82 ft.

8947-08 SE (1)--At Sioux City, on 38th Street bridge over Perry Creek, 40 ft upstream and 85 ft right of gage house, on right upstream corner of bridge handrail, at base of lamppost; chiseled square.

Elevation 1146.46 ft.

8947-08 SE (2)--At Sioux City, on 38th Street bridge over Perry Creek, on upstream side and one foot streamward of gage house, in concrete pillar at ground level; U.S. Geological Survey brass bench mark.

Elevation 1141.79 ft.

8947-08 SE (3)--At Sioux City, on Sioux City Country Club footbridge over Perry Creek, on right upstream concrete walkway; extreme landward corner of walkway.

Elevation 1143.29 ft.

8947-08 SE (4)--(REFERENCE POINT) At Sioux City, on Sioux City Country Club footbridge over Perry Creek, 34 ft streamward from bench mark 8947-08 SE (3), on upstream edge of walkway; chiseled square.

Elevation 1143.73 ft.

8947-17 NE (1)--At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on right downstream wingwall post, on downstream and streamward corner of post; chiseled square.

Elevation 1144.63 ft.

8947-17 NE (2)--(REFERENCE POINT) At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on upstream concrete guardrail, between tenth and eleventh vertical supports from right end of bridge; chiseled square.

Elevation 1142.11 ft.

8947-17 NE (3)--At Sioux City, on 36th Street bridge over Perry Creek, on right downstream bridge guardrail, far right bolt head (rounded carriage bolt); top of bolt head.

Elevation 1145.43 ft.

8947-17 SE (1)--At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on right upstream abutment of bridge, far northeast bolt; top of anchor bolt holding fence support.

Elevation 1133.78 ft.

8947-17 SE (2)--At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on concrete guardrail at left downstream end of bridge; Iowa Highway Commission bench mark.

Elevation 1139.78 ft.

8947-17 SE (3)--(REFERENCE POINT) At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on walkway at thirteenth vertical support from right upstream end of bridge; chiseled square.

Elevation 1135.17 ft.

8947-17 SE (4)--(REFERENCE POINT) At Sioux City, on Stone Park Boulevard bridge over Perry Creek, on walkway at eighth vertical support from right downstream end of bridge; chiseled square.

Elevation 1132.15 ft.

8947-17 SE (5)--At Sioux City, near Dearborn Boulevard bridge over Perry Creek, 30 ft left of left upstream end of bridge, pipe nearest bridge in row of pipes at edge of parking lot of school; top of concrete-plugged, 4-in. pipe.

Elevation 1140.00 ft.

8947-17 SE (6)--(REFERENCE POINT) At Sioux City, on Dearborn Boulevard bridge over Perry Creek, on fifth concrete vertical support from left upstream end of bridge; top of extreme upstream and streamward corner of concrete vertical support

Elevation 1141.26 ft.

8947-20 NE (1)--At Sioux City, on abandoned West 23rd Street bridge over Perry Creek, on right upstream bridge abutment (right downstream end of footbridge); extreme right upstream corner of concrete abutment.

Elevation 1122.34 ft.

8947-20 NE (2)--(REFERENCE POINT) At Sioux City, on abandoned West 23rd Street bridge over Perry Creek, on third vertical support of upstream truss section of bridge; extreme left downstream corner of baseplate.

Elevation 1121.48 ft.

8947-20 NE (3)--At Sioux City, on West 26th Street bridge over Perry Creek, on right downstream guardrail on mainspan of bridge; top of pipe embedded in guardrail.

Elevation 1128.62 ft.

8947-20 NE (4)--(REFERENCE POINT) At Sioux City, on West 26th Street bridge over Perry Creek, on top of third guardrail post from left downstream end of bridge; chiseled square.

Elevation 1128.82 ft.

8947-20 NE (5)--At Sioux City, on West 28th Street bridge over Perry Creek, on concrete guardrail at left upstream end of bridge; extreme left upstream corner of guardrail.

Elevation 1133.25 ft.

8947-20 NE (6)--(REFERENCE POINT) At Sioux City, on West 28th Street bridge over Perry Creek, on concrete guardrail, 5 ft streamward from left downstream guardrail post; chiseled square.

Elevation 1127.68 ft.

8947-20 SE (1)-- At Sioux City, on West 14th Street bridge over Perry Creek, on second guardrail post from right upstream end of bridge; top of extreme left upstream corner of post.

Elevation 1122.54 ft.

8947-20 SE (2)--(REFERENCE POINT) At Sioux City, on West 14th Street bridge over Perry Creek, on center of second guardrail post from right downstream end of bridge; chiseled square.

Elevation 1122.48 ft.

8947-20 SE (3)-- At Sioux City, on Cook Street bridge over Perry Creek, on guardrail at extreme left downstream end of bridge; top of bolt.

Elevation 1121.82 ft.

8947-20 SE (4)--(REFERENCE POINT) At Sioux City, on Cook Street bridge over Perry Creek, on downstream guardrail, 3 ft streamward from bench mark 8947-20 SE (3); three filed marks.

Elevation 1121.77 ft.

8947-20 SE (5)-- At Sioux City, on Hamilton Boulevard over Perry Creek, on left upstream wingwall post; on top of extreme downstream streamward corner of post.

Elevation 1124.65 ft.

8947-20 SE (6)--(REFERENCE POINT) At Sioux City, on Hamilton Boulevard bridge over Perry Creek, on baseplate of ninth guardrail post from left upstream end of bridge, extreme left upstream corner of baseplate.

Elevation 1122.06 ft.

8947-20 SE (7)-- At Sioux City, on West 19th Street bridge over Perry Creek, on right upstream guardrail on main span of bridge; extreme right upstream corner of guardrail.

Elevation 1125.69 ft.

8947-20 SE (8)--(REFERENCE POINT) At Sioux City, on West 19th Street bridge over Perry Creek, on center top of downstream guardrail, 26 ft streamward from right end of bridge; chiseled square.

Elevation 1125.61 ft.

8947-20 SE (9)-- At Sioux City, on West 20th Street bridge over Perry Creek, on guardrail at left downstream end of bridge; extreme left upstream corner of guardrail.

Elevation 1124.90 ft.

8947-20 SE (10)--(REFERENCE POINT) At Sioux City, on West 20th Street bridge over Perry Creek, on downstream guardrail, 26 ft streamward from bench mark 8947-20 SE (9); chiseled square.

Elevation 1124.60 ft

8947-28 NW (1)-- At Sioux City, on Perry Street bridge at entrance to closed conduit for Perry Creek, on wingwall at right upstream corner of entrance to closed conduit; top of bent-over, 1/2-in. rebar.

Elevation 1112.14 ft.

8947-28 NW (2)--(REFERENCE POINT) At Sioux City, on Perry Street bridge at entrance to closed conduit for Perry Creek, on entrance to closed conduit, 5 ft from left end of entrance; chiseled square.

Elevation 1113.28 ft.

8947-28 NW (3)-- At Sioux City, on Bluff Street bridge over Perry Creek, near second guardrail post from right upstream end of bridge, on guardrail and 2 ft right from post, top of 1/4-in. rebar.

Elevation 1114.74 ft.

8947-28 NW (4)--(REFERENCE POINT) At Sioux City, on Bluff Street bridge over Perry Creek, on bolthead of waterline in first clamp from right downstream end of bridge; two chiseled marks.

Elevation 1108.78 ft.

8947-29 NE (1) -- At Sioux City, on Market Street bridge over Perry Creek, on guardrail post at left upstream end of bridge, on left upstream corner of post; top of eye bolt.

Elevation 1112.90 ft.

8947-29 NE (2)--(REFERENCE POINT) At Sioux City, on Market Street bridge over Perry Creek, on top of right downstream support for sewer pipe; three chiseled marks.

Elevation 1112.60 ft.

8947-29 NE (3)-- At Sioux City, on Main Street bridge over Perry Creek, on second guardrail post from right upstream end of bridge, top of extreme left upstream corner of post.

Elevation 1116.73 ft.

8947-29 NE (4)--(REFERENCE POINT) At Sioux City, on Main Street bridge over Perry Creek, on top of right downstream wingwall; chiseled square.

Elevation 1113.09 ft.

9047-02 NW (1)--Approximately 4.2 mi northwest of Hinton, on 280th Street bridge over Perry Creek, on left downstream bridge piling, on downstream side of piling; top of 3/8-in. lag bolt.

Elevation 1258.07 ft.

9047-02 NW (2)--(REFERENCE POINT) Approximately 4.2 mi northwest of Hinton, on 280th Street bridge over Perry Creek, on downstream bridgerail, 32 ft streamward from bench mark 9047-02 NW (1); two filed marks.

Elevation 1262.31 ft.

9047-11 NW (1)--Approximately 4 mi west of Hinton, on County Road C60 bridge over Perry Creek, on top of concrete guardrail at left downstream end of bridge; chiseled square.

Elevation 1250.74 ft.

9047-11 NW (2)--Approximately 4 mi west of Hinton, on County Road C60 bridge over Perry Creek, on top of right upstream guardrail, 5 ft from right end of bridge; metal plug.

Elevation 1249.07 ft.

9047-11 NW (3)--(REFERENCE POINT) Approximately 4 mi west of Hinton, on County Road C60 bridge over Perry Creek, on upstream guardrail, 87 ft streamward from bench mark 9047-11 NW (1); chiseled square.

Elevation 1249.41 ft.

9047-15 NE (1)-- Approximately 4 mi west of Hinton, on 300th Street bridge over Perry Creek, on top of right upstream wingwall; Plymouth County brass tablet stamped "Elev. 1230.62 ft." Elevation obtained from Plymouth County Engineer.

Elevation 1230.62 ft.

9047-15 NE (2)--(REFERENCE POINT) Approximately 4 mi west of Hinton, on 300th Street bridge over Perry Creek, on upstream guardrail, 56 ft streamward from bench mark 9047-15 NE (1); chiseled square.

Elevation 1230.19 ft.

9047-22 SE (1)-- Approximately 2.5 mi north of Woodbury-Plymouth County line, on Lone Tree Road bridge over Perry Creek, on right downstream concrete abutment; top of extreme downstream landward corner of abutment.

Elevation 1205.89 ft.

9047-22 SE (2)--(REFERENCE POINT) Approximately 2.5 mi north of Woodbury-Plymouth County line, on Lone Tree Road bridge over Perry Creek, on downstream bridgerail, 56 ft streamward from bench mark 9047-22 SE (1); two filed marks.

Elevation 1207.82 ft.

9047-27 SW (1)-- Approximately 1.2 mi north of Woodbury-Plymouth County line, on County Road K22 bridge over Perry Creek, on left downstream end of bridge, top of large hex nut on bolt nearest abutment.

Elevation 1181.37 ft.

9047-27 SW (2)--(REFERENCE POINT) Approximately 1.2 mi north of Woodbury-Plymouth County line, on County Road K22 bridge over Perry Creek, on top of sixteenth vertical support streamward from bench mark 9047-27 SW (1); two filed cuts.

Elevation 1183.15 ft.

9047-27 SW (3)--Approximately 1.5 mi north of Woodbury-Plymouth County line, on 325th Street bridge over Perry Creek, on large wood piling base at right downstream bridge abutment; top of 3/8-in. lag bolt.

Elevation 1178.78 ft.

9047-27 SW (4)--(REFERENCE POINT) Approximately 1.5 mi. north of Woodbury-Plymouth County line, on 325th Street bridge over Perry Creek, on downstream bridgerail at sixth vertical support from bench mark 9047-27 SW (3); two filed marks.

Elevation 1183.54 ft.

9047-33 SW (1)--Approximately 0.25 mi north of Woodbury-Plymouth County line, on South Ridge Road bridge over Perry Creek, on left downstream vertical guardrail support; top of large hex nut.

Elevation 1173.05 ft.

9047-33 SW (2)--(REFERENCE POINT) Approximately 0.25 mi north of Woodbury-Plymouth County line, on South Ridge Road bridge over Perry Creek, on nineteenth downstream vertical guardrail support streamward from bench mark 9047-33 SW (1); three filed marks.

Elevation 1175.72 ft.

9147-12 NW (1)--Approximately 5 mi west of Merrill, on County Road C44 bridge over Perry Creek, on top of right downstream wingwall; Plymouth County brass tablet. Elevation obtained from Plymouth County Engineer.

Elevation 1338.87 ft.

9147-12 NW (2)--(REFERENCE POINT) Approximately 5 mi west of Merrill, on County Road C44 bridge over Perry Creek, on downstream side of concrete guardrail, 37.5 ft from left downstream bridge abutment; top of end of 3/8 in. anchor stud set in concrete guardrail.

Elevation 1338.22 ft.

9147-14 NE (1)--Approximately 5.6 mi west of Merrill, on 240th Street bridge over Perry Creek, on left downstream end of bridge; top of large bolt head holding truss plate.

Elevation 1311.57 ft.

9147-14 NE (2)--(REFERENCE POINT) Approximately 5.6 mi west of Merrill, on 240th Street bridge over Perry Creek, on top of downstream guardrail, 24 ft streamward from bench mark 9147-14 NE (1); three filed marks.

Elevation 1318.30 ft.

9147-15 SE (1)--Approximately 6 mi northwest of Hinton, on County Road K22 bridge over Perry Creek, on corner of left downstream abutment; Iowa Highway Commission bench mark.

Elevation 1304.38 ft.

9147-15 SE (2)--(REFERENCE POINT) Approximately 6 mi northwest of Hinton, on County Road K22 bridge over Perry Creek, on downstream guardrail curb, 60 ft streamward from bench mark 9147-15 SE (1); chiseled square.

Elevation 1304.85 ft.

9147-22 NE (1)-- Approximately 6 mi northwest of Hinton, on 250th Street bridge over Perry Creek, in wingwall piling at left downstream end of bridge; top of 3/8-in. lag bolt.

Elevation 1300.33 ft.

9147-22 NE (2)--(REFERENCE POINT) Approximately 6 mi northwest of Hinton, on 250th Street bridge over Perry Creek, on downstream guardrail, 34 ft streamward from bench mark 9147-22 NE (1); two filed marks.

Elevation 1305.56 ft.

9147-26 SW (1)--Approximately 4.7 mi northwest of Hinton, on 270th Street bridge over Perry Creek, on top of right upstream wingwall; Plymouth County brass tablet stamped "Elev. 1274.79." Elevation obtained from Plymouth County Engineer.

Elevation 1274.79 ft.

9147-26 SW (2)--(REFERENCE POINT) Approximately 4.7 mi northwest of Hinton, on 270th Street bridge over Perry Creek, on downstream bridgerail, 64 ft streamward from right end of bridge; chiseled square.

Elevation 1274.15 ft.

9147-26 NW (1)--Approximately 5.2 mi northwest of Hinton, on County Road K22 bridge over Perry Creek, near abutment at right downstream end of bridge, on T-beam holding guardrail; top of large bolt nut nearest abutment.

Elevation 1289.93 ft.

9147-26 NW (2)--(REFERENCE POINT) Approximately 5.2 mi northwest of Hinton, on County Road K22 bridge over Perry Creek, on right downstream end of bridge, on top of ninth vertical support streamward from bench mark 9147-26 NW (1); two filed marks.

Elevation 1291.90 ft.

9247-25 SE (1)--Approximately 4.6 mi northwest of Merrill, on County Road C38 bridge over Perry Creek, in concrete abutment at left upstream end of bridge; top of rebar.

Elevation 1373.89 ft.

9247-25 SE (2)--(REFERENCE POINT) Approximately 4.6 mi northwest of Merrill, on County Road C38 bridge over Perry Creek, on guardrail, 27 ft streamward from bench mark 9247-25 SE (1); two filed marks.

Elevation 1374.28 ft.

9247-25 SE (3)--Approximately 4.6 mi northwest of Merrill, on County Road K30 bridge over Perry Creek, in top of wood piling at left downstream wingwall; top of 3/8-in. lag bolt.

Elevation 1375.26 ft.

9247-25 SE (4)--(REFERENCE POINT) Approximately 4.6 mi northwest of Merrill, on County Road K30 bridge over Perry Creek, on downstream side of bridge, 8 ft streamward from bench mark 9247-25 SE (3); top of 3/8-in. lag bolt.

Elevation 1375.29 ft.

9247-36 SE (1)-- Approximately 4.3 mi west of Merrill, on 220th Street bridge over Perry Creek, in wood piling of wingwall at right upstream end of bridge; top of 3/8-in. lag bolt.

Elevation 1346.67 ft.

9247-36 SE (2)--(REFERENCE POINT) Approximately 4.3 mi west of Merrill, on 220th Street bridge over Perry Creek, on upstream side of bridge, 28 ft streamward from bench mark 9247-36 SE (1); top of 3/8-in. lag bolt.

Elevation 1349.85 ft.